vented and we shall be glad to publish them if communicated by our observers.

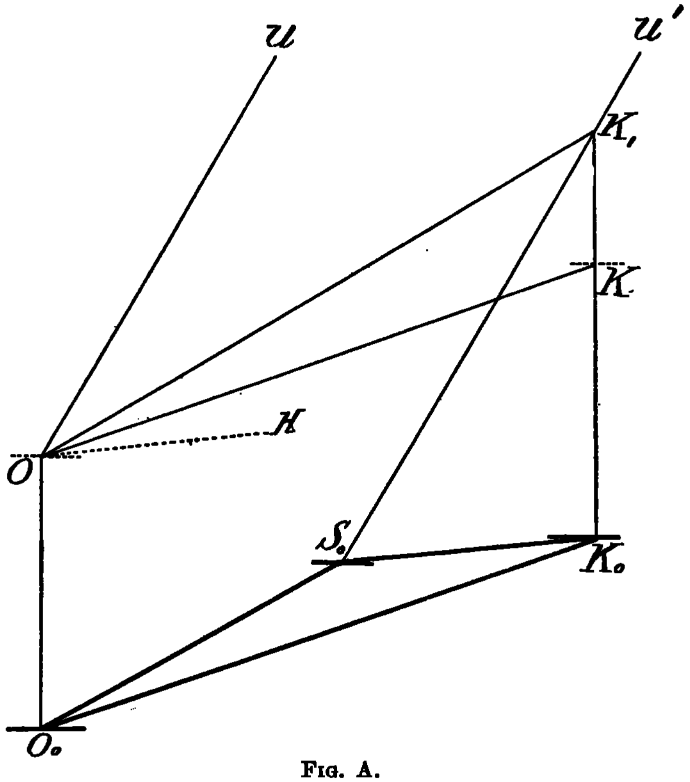

FIG. A.

In Fig. A let O be the observer and O_0 a point below him on the level of the observed shadow of the cloud. Let K_1 be the cloud and S_0 its shadow, the sun being at U or U'. Let K_0 be a point vertically below the cloud and on the same level as S_0. The points O_0, S_0, and K_0 are all on the same lower level and the azimuths, as measured at O, being measured in a horizontal plane, will be the same as the azimuths of these three horizontal lines forming the triangle $S_0O_0K_0$. The azimuths may be measured either from the south point westward or in any other manner most convenient to the observer it matters not which, as only the differences come into consideration at present. The observations are most naturally made in the following order: First, identify the cloud with its shadow and locate the shadow by a mark on the detailed topographical map, as at S_0 in Fig. A and also note the time. The observer at O must then immediately, with his nephoscope, or an equivalent alt-azimuth instrument, observe the apparent altitude of the cloud (or the angle K_1OK or h_1); the azimuth of the cloud (or the azimuth of the line OK or O_0K_0, which is a_1); the apparent altitude of the sun (the angle UOH or $U'S_0K_0$, which is h_2); the apparent azimuth of the sun (which is the azimuth of the line OH, or the parallel line S_0K_0 or a_2). He then determines at his leisure by measurement on the map the azimuth of the cloud shadow (which is the azimuth of the line O_0S_0 or a_3); the distance of the shadow (which is O_0S_0 or b); finally, the difference in level between O and S_0, as shown by the contour lines (which is c or the vertical lines OO_0 or KK_0).

We now have the following simple trigonometrical relations:

$$K_0\,O_0\,S_0 = A_2 = a_3 - a_1$$
$$S_0K_0\,O_0 = A_3 = a_1 - a_2$$
$$O_0\,S_0\,K_0 = A_1 = a_2 - a_3 + 180^\circ$$

Thus all the angles and the side O_0S_0 are known in the triangle $O_0S_0K_0$. The subsequent work consists in computing the other sides O_0K_0 and S_0K_0, which are respectively the bases of two vertical right-angled triangles, in which we know the vertical angles KOK_1 or h_1, and $K_0S_0K_1$ or h_2. With these we now compute both KK_1 or z_1, which is the height of the cloud above the horizontal plane through O and also K_0K_1, which is the height of the cloud above the horizontal plane through O_0. From the latter we subtract the known quantity K_0K or O_0O which leaves KK_1; the latter is, therefore, a second computed value, which should agree with the one just previously computed from the triangle KOK_1. The entire system of formulæ for the solution is as follows:

$$O\,K = O_0\,K_0 = \sin A_1 \frac{b}{\sin A_3};\quad K K_1 = z_1 = O_0K_0 \tan h_1$$

$$S_0K_0 = \sin A_2 \frac{b}{\sin A_3};\quad K_0K_1 = z_2 = S_0K_0 \tan h_2$$

$$z_1 = b \operatorname{cosec} A_3 \tan h_1 \sin A_1$$
$$z_2 - c = b \operatorname{cosec} A_3 \tan h_2 \sin A_2$$
$$z_m = \tfrac{1}{2}(z_1 + z_2 - c)$$
$$\Delta z = z_1 - (z_2 - c)$$

If the shadow be watched for a few seconds and located again on the chart or at S_0' then these two locations give directly the direction of motion and the velocity of the shadow, which are the same as for the cloud.

The two values z_1 and $z_2 - c$ evidently ought to agree closely with each other, but for a number of reasons discrepancies are generally present. These arise mostly from the fact that the centre of the cloud as observed from O is not necessarily identical with that portion of the cloud that corresponds to the centre of the shadow. This fact becomes apparent as soon as we consider the very irregular shapes of the clouds. The two centers could only coincide when the cloud is a symmetrical figure. The same would be true if instead of the shadow at S_0 an observer had been stationed there with his theodolite and simultaneous observations had been made without reference to the sun. In general, the lines of sight from O and S_0 will pass through the cloud, but they may pass by each other without intersecting, or they may intersect at some point much nearer or farther than the cloud. In addition to this principal source of discrepancy there are unavoidable errors of pointing and measuring to be considered which may aggravate the error of the assumption just explained. The question therefore recurs which of the computed values of z is to be adopted or what combination of them will give the most probable result. Different students have adopted different rules in this matter, *e. g.*, Ekholm and Hagstrom adopt the location of the center of the shortest line that can be drawn between the two sight lines OK_1 and S_0K_0; that is to say, if these lines do not intersect as they ought to do Ekholm adopts the point of nearest approach to intersection. As this involves much extra computation, Professor Bigelow adopts the simple average of the two computed altitudes. In very accurate measurements, where all sources of error are carefully attended to and where the observed point is very definite as in geodesy, the method of Ekholm and Hagstrom is preferable, but in cloud work, where the observers are almost inevitably sighting upon different points of the same cloud, their method may have no advantage over that of Professor Bigelow. The proper combination of two or more observations so as to determine the most probable height of some definite point within a cloud, and thence the location of the top and bottom points of the cloud, is a question still to be settled.

THE FRANKLIN KITE CLUB.

In the MONTHLY WEATHER REVIEW for 1896, pp. 114, 206, 334, and 416, we have quoted a reference to the Franklin Kite Club at Philadelphia, and its report on the discovery of ascending columns of air, as printed by Espy at page 167 of his Philosophy of Storms. The Editor has recently discovered that this reference to the Kite Club, as well as the whole of pages 161–168 of the Philosophy, is quoted by Espy from pp. 34–40 of an Essay on Meteorological Observations, by J. N. Nicollet, which essay is dated May 6, 1839. Nicollet, in these pages, fully indorses Espy's views, which, as he says, are recommended by the American Philosophical Society of Philadelphia, and it is quite possible that he has simply reproduced some one of Espy's numerous writings, however, Nicollet's pamphlet enables us to conclude with considerable confidence that the report of the Franklin Kite Club was published in or before 1838. No copy of this report has, as yet, been discovered, and it is considered exceedingly desirable that copies should, if possible, be deposited in some of the larger public libraries, where they will be preserved on account of their historical interest.

If any of the older meteorological observers possess copies of the circulars and instructions issued by Espy or the Joint Committee, during the years 1834–40, or if they possess newspapers containing reports of Espy's lectures, or any other matters of interest in the history of meteorology, the Editor will be glad to hear from them. Old manuscripts, papers, and pamphlets that have descended from one generation to another until they have become an incubus should never be destroyed or sold for waste paper until some competent librarian or historian has had an opportunity to examine them thoroughly and decide whether they are not worth purchasing and preserving permanently.

THE KITE AS USED BY ESPY.

Even before the work done by the Franklin Kite Club we note that Espy used the kite to determine the altitude of clouds as a check upon his computations, based on the dew-point of the air near the surface of the ground. His active mind had perceived that the altitude of the base of a cloud depends upon the rate of cooling of ascending moist air. The following paragraph must have been written between 1833 and 1837, and is quoted from page 75 of Espy's Philosophy of Storms:

I would recommend that gentlemen residing in mountainous districts, where the clouds sometimes form on the sides of the mountains, should ascertain the perpendicular heights of these clouds at their bases and see whether they are 100 yards high for every degree of Fahrenheit by which the temperature of the air is above the dew-point at the moment of their formation. * * * Since writing the above a kite was sent up into the base of a cloud and its height ascertained by the sextant and compared with the height calculated from the dew-point, allowing 100 yards for every degree by which the dew-point was below the temperature of the air, and the agreement of the two methods was within the limits of the errors of observation. In this case the base of the cloud was over 1,200 yards high. Moreover, the motions of the kite whenever a forming cloud came nearly over it proved that there was an upmoving column of air under it. I speak of cumulus clouds in the form of sugar loaves with flat bases.

In his third meteorological report, paragraph 81, written about November, 1850, and reprinted also as paragraph 81 in his fourth report, Espy says:

When the kite experiments mentioned before were performed and the kite was allowed to stay up in the air many hundred yards high in the night, by touching with the hand the reel on which the wire was wound which was attached to the kite, the *fingers became luminous*, quite brilliant, though no sensation of a shock was produced; but by touching the wire itself a very pungent shock was experienced; and one day in particular when the kite entered the base of a forming cloud the discharge of electricity down the wire, snapping to an iron conductor stuck in the ground, terminating at its upper end within an inch or two of the wire, became fearful.

In the case of the meteoric rivers (*i. e.*, cloudbursts) the friction of the water through the air in falling might be supposed to generate electricity which rendered them luminous; but the friction of the wind on a kite eight feet square could evidently not be sufficient to account for the great quantity of electricity constantly passing down the wire; indeed the shock on touching the wire became quite sharp when the kite was elevated a few hundred feet, even in a clear sky. *After all, it must be acknowledged that the utility of electricity is yet to be discovered, as also its mode of generation and the part it plays in storms.*

The evolution of latent caloric in the formation of cloud is undoubtedly adequate to account for all the phenomena attending storms, with but two or three exceptions noticed before, which may probably be produced by electricity—in a mode, however, not yet exactly known.

In the paragraphs preceding No. 81 there is nothing relative to kite experiments; it seems likely that Espy intended to refer to his Philosophy of Storms and to the kite experiments made by himself and the Franklin Kite Club in Philadelphia. In this case we see that as early as 1836 metallic wire was used instead of string in Philadelphia.

THE KITE USED IN 1822 BY FISHER.

The Editor has several times called attention to the fact that the first to apply the kite to meteorological investigations was the eminent Prof. William Wilson, of Glasgow University, who in 1749 obtained the temperatures at great elevations by means of self-registering minimum thermometers carried up by means of a kite or tandem of kites. In a recent note on this subject by our distinguished co-laborer Mr. G. J. Symons, the learned editor of the Monthly Meteorological Magazine, he states that the next use of the kite for determining temperatures was that made by Rev. George Fisher and Capt. Sir William Edward Parry (at the Island of Igloolik, latitude 69° 21′ N., longitude 81° 42′ W., during Parry's "second voyage" in 1822–23). Mr. Symons quotes the account as published by Harvey, in the Encyclopedia Metropolitana, article, "Meteorology," published in 1834. The experiment by Fisher is one that had long been known to the present Editor, although he was not until now aware of Harvey's reference to it. The original account quoted by Harvey is contained in a letter from Fisher addressed to Dr. Thomas Young as editor of the Quarterly Journal of Science and Arts, published by the Royal Institution of Great Britain (see Vol. XXI, 1826, page 348); it is followed by some notes by Dr. Young, on page 359, both of which we quote as follows:

WANSTED VICARAGE, ESSEX, *23d Feb.*, 1826.

I have enclosed some of the observations upon the refraction at low temperatures and altitudes, made at the island of Igloolik, N. E. coast of America. And as the law of variation in the temperature of the atmosphere at different heights is connected with the theoretical investigation of the subject, I take the opportunity of mentioning an experiment made by Captain Parry and myself for determining it.

This was done by means of a paper kite, to which was attached an excellent register thermometer, in a horizontal position. Its height above the level of the frozen sea, upon which the experiment was made, was determined by two observers in the same vertical plane, taking its altitude at the same time above the distant horizon; and from thence its height was computed. The greatest height observed was 379 feet, at which height it was nearly stationary for about a quarter of an hour. It probably, however, had been more than 400 feet above the sea. After an unsuccessful attempt, the experiment was made under very favourable circumstances, the kite being sent up and caught in coming down, without the slightest shake. The indices had not altered their position in the slightest degree, and they would have indicated any variation of temperature, had it existed, to less than a quarter of a degree Fahr. The temperature at the time was —24° Fahr.

I have also enclosed Dr. Brinkley's table of refractions, adapted to temperatures as low as —50° Fahr., which he was kind enough to send me.

From, Dear Sir, yours truly. GEO. FISHER.

Note on the above by Dr. Thomas Young on page 359:

The observations of Mr. Fisher and of Mr. Foster fully justify the remark already made in the thirteenth number of these collections, (Vol. XV, p. 128), that the refractions at low temperatures, as indicated by Dr. Young's table, which are found to be somewhat greater than those which Mr. Groombridge has observed in this country, would probably be found to be less in *excess* when applied to colder climates. That they would, however, have been actually so much in *defect* as these observations have demonstrated, could not have been foreseen without actual trial. The theory is indeed greatly illustrated by Mr. Fisher's very valuable experiment with the kite, which shows that the law of decrease of temperature must be supposed to be very differ-